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Assessment of physicochemical parameters with its effects on human and aquatic animals giving special preference to effective management of Turag River

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Abstract: *Rapid acceleration of urbanization and industrialization in Bangladesh has been coupled with increasing environmental deterioration. The present survey was conducted to monitor the physicochemical parameters that are ruined due to excess pollution load. Water and sediment samples were collected from five stations along Turag River. The ranges of CO, CO_2, NO_x and PM_{10} concentrationswere varied for CO: 2421–7633 µg/m^3, 383-501 µg/m^3 for CO_2, 81–648 µg/m^3 for NO_xand150.92–553.43 µg/m^3 for PM_{10} that were detected using Gastec technique. Atomic absorption spectrophotometer (AAS) approach was employed to examine the value of Cr, Pb, Zn, Cu and Cd. Metal concentrations ranged between 0.10–0.90 for Cd, 31.00–78.20 for Cr, 48.10–69.00 for Cu, 30.30–37.20 for Pb and 95.60–191.10 mg/kg for Zn in the sediment samples. Occurrence of both the air pollutants and sediment heavy metal differed amongfive stations that was analyzed by using ANOVA (SPSS V.17) test. Major pollution sources were domestic sewage, industrial waste, commercial waste, agricultural waste, institutional waste, street sweepings and construction debris etc. Solid waste pollution, heavy metal pollution, organochlorine pesticides pollution and oil pollution are highly responsible for environment degradation in the study area during the sampling period. Air and water temperature varied from 26–36(°c) and 29–34(°c) respectively.p^H, EC, Chloride, Turbidity, TS, TDS, DO, BOD(day 5) and COD concentrations in water samples were found to range from 7.5–7.9, 1850-1900(µ$Scm^{-1)}$, 32–42(mg/L), 13.5–14.4cm, 902–970(mg/L), 810–850(mg/L), 0–0(mg/L), 21–24(mg/L), and 106–141(mg/L) respectively. These results provide an evidence that higher concentration of heavy metal is detrimental to human and aquatic animals for physical disorder and fisher folks are suffering from various diseases like skin disease andirritation.*

Keywords: *Environment; ANOVA; Degradation; Heavy metal; Fisher folk; Management*

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I. Introduction

TuragRiver is one of the most polluted rivers in Bangladesh (Banuet al., 2013). It is geographically and economically important due to its location in capital city, Dhaka. A lot of mills and factories have been set up in and around the Dhaka city during the last few decades, and the number of new industries are continually increasing (DoE, 1997). The most vital and crucial element among the natural resources is water, praying need for the survival of all living organisms including humans, food production and economic development (Shiklomanov, 1993; Pahl-Wostlet al. 2008). Recently, nearly 40% of the world’s food supply is grown under irrigation, and wide varieties of industrial processes rely on water (BCAS, 2000). Water is unavoidably essential butindustrial units are polluting the study area unremittingly (Banu et al., 2013). Severe pollutionsoccurred at Buriganga Third Bridge area at Bashila and the Tongi Bridge area. At these two points, the river water is pitch-black with the worst of smell and can be usedhardly for any purpose. Besides, near the Tongi Bridge extreme pollution happened that derives massive pollutant loading from the Tongi industrial area that includes about 32 heavy industries and generates tons of effluents daily, which contain lots of heavy metal. Pb,Cd, Cr, Zn, Cu and Fe that found in contaminated soils (Akotoet al, 2008) whichcreated from vehicle exhausts, as well as from many industrial happenings (Ghrefat and Yusuf, 2006). Elevating nutrients leading to eutrophication and pollution in the aquatic environment (Nriagu and Pacyna, 1988; Peierls et al. 1998; Holloway et al. 1998; Li et al. 2009; Pekey et al. 2004, Venkatramanan et al. 2013, 2014a, b). The signs of autism, PDD, Aspergers, & ADD/ ADHD and the signs of toxic heavy metal poisoningare very similar. Toxic metals could be the cause of those signs. Depression, high blood pressure,increased allergic reactions, irritability, memory loss, poor concentration, aggressive behavior, fatigue, speech disorders, sleep disabilities, cholesterol, triglycerides, vascular occlusion, neuropathy and autoimmune diseases are just some of the many conditions resulting from exposure to toxins (Thomilson et al. 1980; Ghrefat and Yusuf, 2006). Eye irritation, sleepiness, throat crossness, tenacious cough, asthma, nose blockage, respiratory contaminations, bronchial impurities, colds and headaches in human being are the result of air pollution (Ahmmed et al. 2010). However, river ecosystem play a tremendous role in terms of the ecology and the economy, surveys on Turag River in Bangladesh is limitedthat led us to continue the present research. The aims of the present study were: (1) to reveal the water and air quality among five stations (2) to demonstrate the effects of pollution and its sound management of TuragRiver.

II. Materials and methods

Water and sediment samples were collected over a 1-month period (August 2015) from Tongi Bridge (23˚52 '54.21"N, 90˚24'4.12"E), World Estema Field (23˚52 '45.54"N , 90˚23'36.98"E), Kamarpara Bridge (23˚53 '25.68"N, 90˚23'23.56"E),Taltola Bridge (23˚53'54.93"N, 90˚22'40.92"E) and AshuliaBeri Bandh (23˚53 '23.34"N, 90˚21'37.45"E) (Fig. 1). The biological oxygen demand (BOD), chemical oxygen demand (BOD), total dissolved solid and total suspended solid were examined by the method stated by APHA, 2005. Dissolve oxygen (DO) calculatedaccording to Azide Modification of Winkler (1988).p^H of water was computed by using p^H paper (color p^H indicators strips, Cat.9585, made in Germany). Heavy metal (Cd, Cr, Hg, Pb)were analyzed by using air acetylene flame with combination as well as single element hollow cathode lamps into an atomic absorption spectrophotometer Shimadzu, AAS-6800 (Ahmed et al, 2010; Subramanian, 2012). Gastec technique (Japanese origin) was usedto calculate the concentration value of CO, CO_2, NO_x and SO_2. High Volume Air Sampler (Graseby Andersen) was employed for PM_{10} concentration determination. Experiments were dealt in accordance with the procedure suggested by the producers of the equipment.

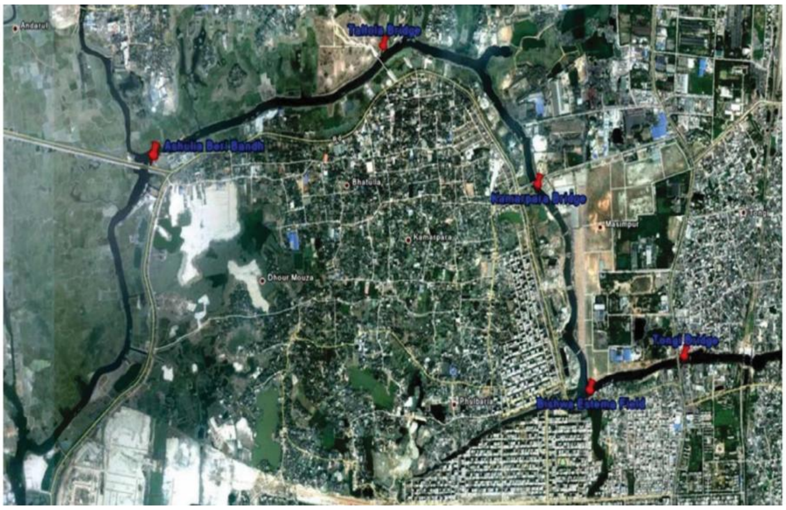

Fig. 1: Map of the study area showing the different sampling stations: site-1: Tongi Bridge; site-2: World Estema Bridge; site-3: Kamarpara Bridge; site-4: Taltoli Bridge; site-5: AshuliaBeri Bandh

III. Results

The ambient physicochemical parametersamong five stations at TuragRiverare presented briefly in the following tables (Tab. 1-12) and figures (Fig. 2-10).

Table-1: Physical and chemical parameters of Turag River water

Parameters	Site-1	Site-2	Site-3	Site-4	Site-5
Air temperature (°c)	27	31	27	34	36
Water color	Pitch black	Pitch black	Pitch black	Pitch black	Pitch black
Water temperature (°c)	30	30	28	34	32
p^H	7.4	7.7	7.9	7.5	7.7
EC (μScm^{-1})	1850	1900	1877	1880	1861
Chloride(mg/L)	35	39	42	35	32

Turbidity(cm)	13.6	14	14.4	13.7	13.5
TS(mg/L)	920	970	953	941	902
TDS(mg/L)	820	850	825	810	812
DO(mg/L)	-	-	-	-	0.1
BOD(mg/L)	24	23	22	21	22
COD(mg/L)	106	120	141	123	112

Table-2: Air quality status of TuragRiver

Location	Pollutant's Concentration					Amended Bangladesh Standards [ECR,2005]	
	CO (μg/m ^{3})	NO_x (μg/m ^{3})	SO_2 (μg/m ^{3})	PM_{10} (μg/m ^{3})	CO_2 (ppm)	Pollutant's Concentration (μg/m ^{3})	
Tongi Bridge	2421	363	Trace	553.43	465	SO_2	365
World Estema Field	7633	648	Trace	270.92	383	CO	10000
Kamarpara Bridge	5530	334	Trace	380.46	497	NO_x	100
Taltola Bridge	2435	81	Trace	150.92	498	PM_{10}	150
AshuliaBeri Bandh	4926	110	Trace	187.64	501		

Table-3: One-Way Analysis of variance of CO at different stations in Turag River

CO	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.800E7	4	2.450E7	1.053E8	.000
Within Groups	4.653	20	.233		
Total	9.800E7	24			

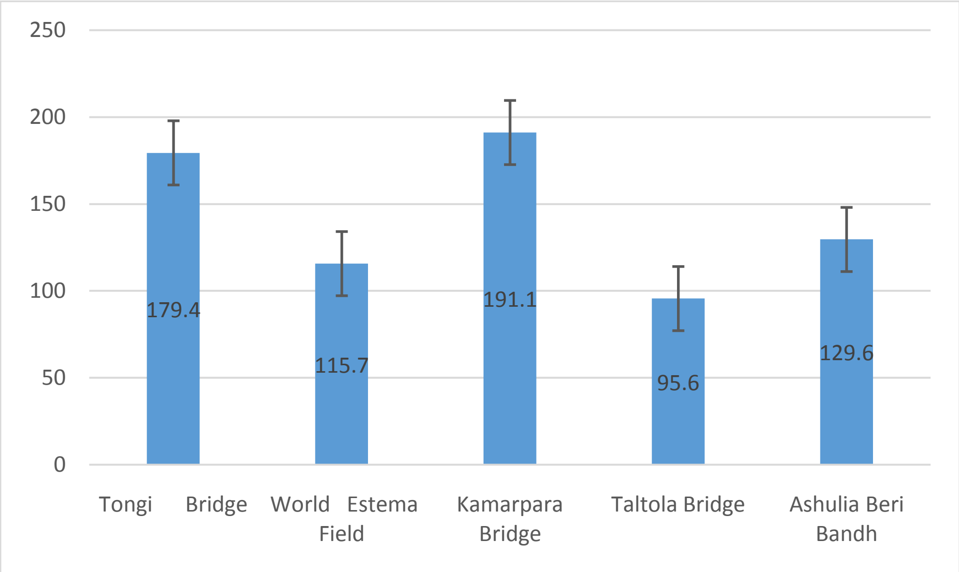

Figure-2: Standard error bar shows significant difference of CO concentration at different stations in Turag River

Table-4: One-Way Analysis of variance of NOx at different station in Turag River

NOx	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1061584.000	4	265396.000	1698534.400	.000
Within Groups	3.125	20	.156		
Total	1061587.125	24			

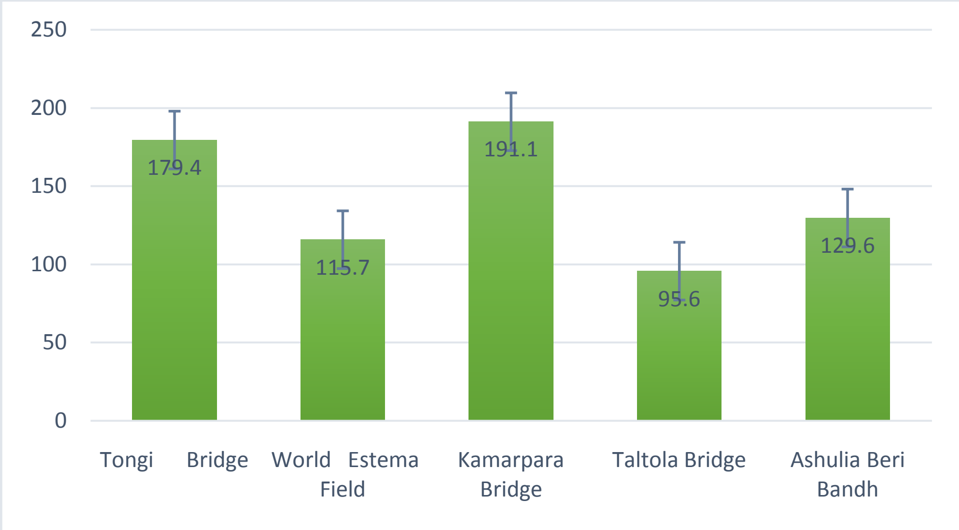

Figure-3: Standard error bar shows significant difference of NO_x concentration at different stations in TuragRiver

Table-5: One-Way Analysis of variance of PM_{10} at different station in Turag River

PM_{10}	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	529118.985	4	132279.746	5678217.132	.000
Within Groups	.466	20	.023		
Total	529119.451	24			

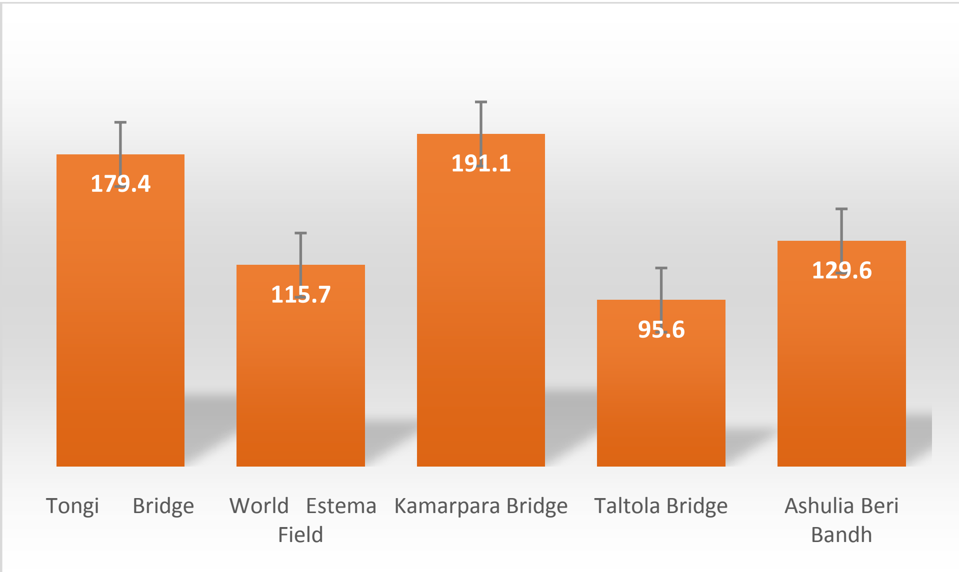

Figure-4: Standard error bar shows significant difference of PM_{10} concentration at different stations in TuragRiver

Table-6: One-Way Analysis of variance of CO_2 at different station in TuragRiver

CO_2	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	43621.108	4	10905.277	68670.435	.000
Within Groups	3.176	20	.159		
Total	43624.284	24			

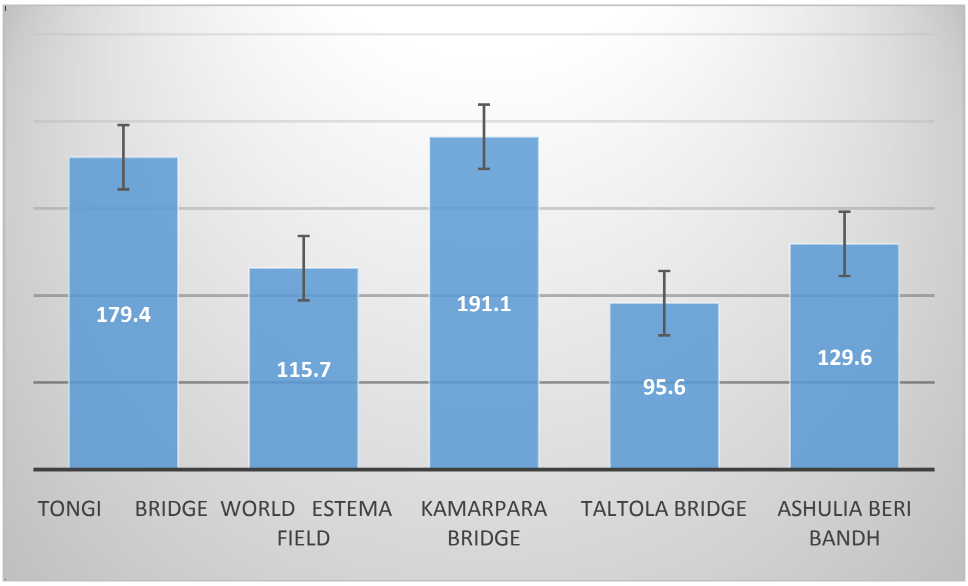

Figure-5: Standard error bar shows significant difference of CO_2 concentration at different stations in TuragRiver

Table-7: Concentration of heavy metals (mg/kg dry weight) of sediments of TuragRiver.

Location	Lead (Pb)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Zinc (Zn)
Tongi Bridge	34.21	0.20	35.60	70.00	179.40
World Estema Field	33.32	0.30	34.40	46.10	115.70
Kamarpara Bridge	31.30	0.10	77.20	47.15	191.10
Taltola Bridge	30.15	0.30	32.00	50.00	95.60
AshuliaBeri Bandh	35.60	0.90	39.50	49.80	129.60
Mean±SD	33.84±2.899	0.36±0.313	43.98±19.378	53.13±8.968	142.28±41.254
Max	37.20	0.90	78.20	69.00	191.10
Min	30.30	0.10	31.00	47.75	95.60

Table-8: One-Way Analysis of variance of Pb at different stations in Turag River

Lead	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	173.042	4	43.260	15916.263	.000
Within Groups	.054	20	.003		
Total	173.096	24			

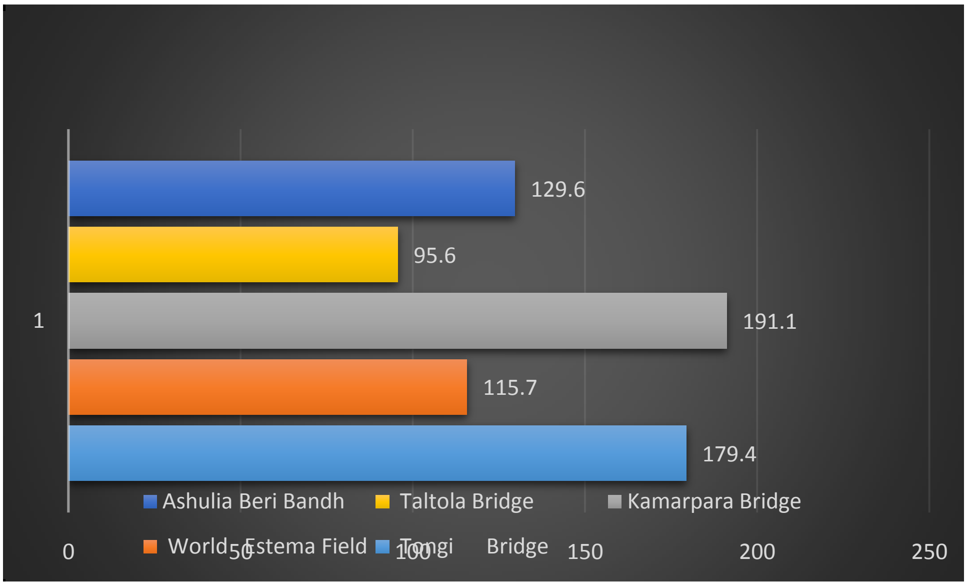

Figure-6: Bar chart shows significant difference of Lead concentration at different stations in TuragRiver

Table-9: One-Way Analysis of variance of Cd at different station in Turag River

Cadmium	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	1.993	4	.498	2147.353	.000
Within Groups	.005	20	.000		
Total	1.997	24			

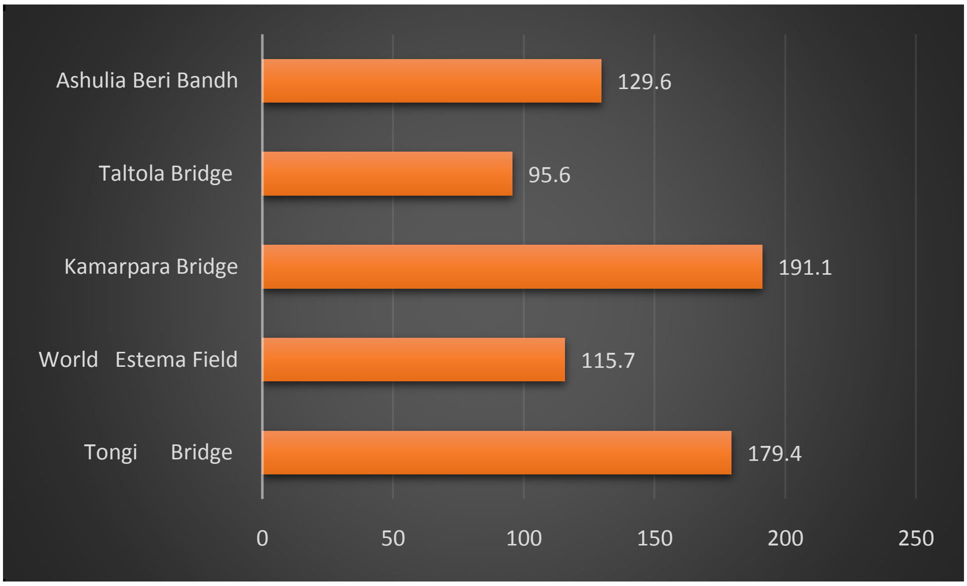

Figure-7: A clustered bar chart shows significant difference of Cadmium concentration at different stations in TuragRiver

Table-10: One-Way Analysis of variance of Cr at different stations in TuragRiver

Chromium	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	7503.485	4	1875.871	380810.259	.000
Within Groups	.099	20	.005		
Total	7503.584	24			

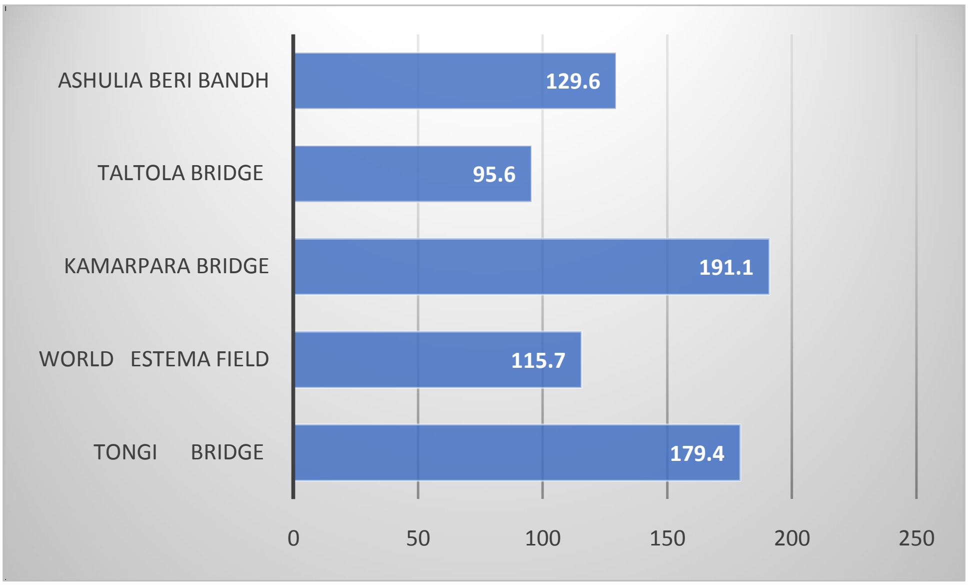

Figure-8: A clustered bar chart shows significant difference of Chromium concentration at different stations in TuragRiver

Table-11: One-Way Analysis of variance of Cu at different stations in TuragRiver

Copper	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	1606.574	4	401.643	36387.333	.000
Within Groups	.221	20	.011		
Total	1606.794	24			

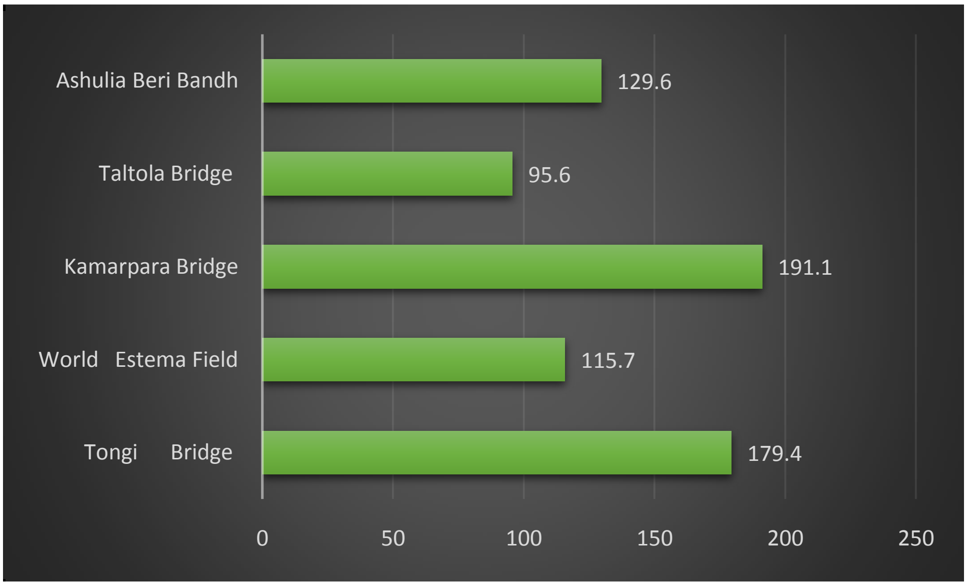

Figure-9: A clustered bar chart shows significant difference of Copper concentration at different stations in TuragRiver

Table-12: One-Way Analysis of variance of Zn at different stations in TuragRiver

Zinc	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	34097.296	4	8524.324	1144819.229	.000
Within Groups	.149	20	.007		
Total	34097.445	24			

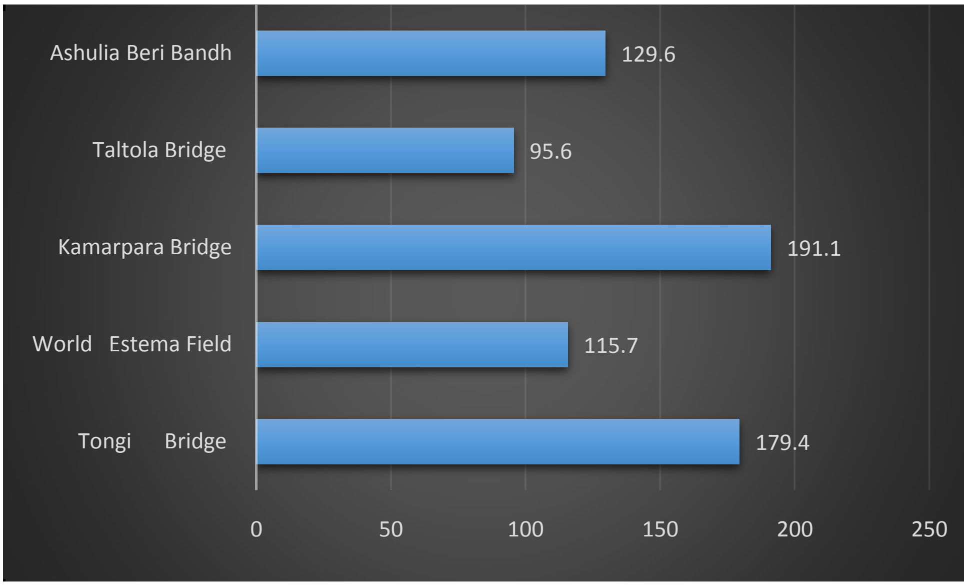

Figure-10: A clustered bar chart shows significant difference of Zinc concentration at different stations in TuragRiver

IV. Discussion

Present study clearly indicates that the recent state of TuragRiver is at risk. Previous investigations proved that Turag became a dead river (Ahmed et al. 2010) which is persistent with the present study, for example, the value of DO in the study area is 0 mgL^{-1}(Tab. 1) which means that the study river is almost dead.More or less similar observations were also recorded by Alam et al. (1996),Jashimuddin and Khan (1993), Hossain and Khan (1992), Islam and Khan (1993), Hossain et al. (1988),Gasim et al. (2007),Bhuyian (1979), Khan et al. (1976) and Mahmood and Bhuyian (1988). The value of p^H showed slightly alkaline in nature. Roy (1955), Moore (1972), APHA (1976), Mahmood and Bhuyian (1988), Sarma et al. (1982) and Campbell (1978) stated that the industrial or municipal waste materials significantly influence the role of increasing or decreasing p^H of the adjacent water bodies where the waste materials were dumped. This statement closely established with the present findings (Tab. 1) (Hossain et al. 2005).The BOD varied from 21‒24 mg/L (Tab. 1), nearly similar result also observed by Kamal et al. 2007 at Mouri River. River water contains BOD more than 10mg/Lis considered to be moderately and more than 20 mg/L as to be highly polluted water (Paul, 1999). COD ranges from 106‒141 mg/L (Tab. 1), closely similar opinion was given by Jamaluddin and Nizamuddin(2012) who surveyed in Chittagong region and Miah(2012) who surveyed in wastewater. According to Nianet al. (2007)higher COD value can cause a substantial damage to submersed plants. Like BOD, higher COD is also harmful to all aquatic lives. The highest value of Pb found in Tongi Bridge 37.20 mg/kg (Tab. 7, 8; Fig. 6). Khan et al. (1998) found the Pb value ranged from 2.355‒26.086 mg/kg in sediment in Ganges‒Brahamputra‒Meghna Estuary. The value of Zn found 95.60‒91.10 mg/kg (Tab. 7, 12; Fig. 10) in the Turag River sediments that is more or less related with the findings of Ashraful (2003) and Neff (2002). The value of Cd was found 0.10‒0.90mg/kg (Tab. 7, 9; Fig. 7) which is nearly similar to the result of Siddique and Akter (2012) who studied trace metal in saltmarsh bed. The value of Cr varied from 31.00‒78.20 mg/kg (Tab. 7, 10; Fig. 8) which shows more or less homology with the outcome of Saha and Hossain (2011) who studied heavy metal contamination and sediment quality in the Buriganga River.The Department of Environment (DoE) and Government of Bangladesh (GoB) set the standard limits of air pollutants are included but from the experimental values, it is apparent that in terms of PM_{10} the situation is alarming which shows similar result with the result of Begum (2004) and Ahmed et al. (2010).The concentration level of CO (Tab. 2; Fig. 2) is within the limit of Bangladesh Standards [ECR, 2005]. However, the concentrations of NO_x(Tab. 2; Fig. 3) in the ambient air exceed the standard values set by the DoE and GoB. Nevertheless, it may be mentioned here that the standard value of NO_x set by the DoE is annual average. The above data indicates that the Turag River in Dhaka city is highly polluted. In summary, these pollutants, when dumped, are polluting the water ecosystems and nearby soil including human society thus greatly rendering us a highly polluted environment.

Water Pollution and Industrial Pollution Control

- (Environment, Forestry and Biodiversity conservation, Background Paper for Seventh Five Year Plan).
- Bangladesh River Basin Pollution Control Project.
- Introduction of Environmental Management System (EMS) in Textile

- Know the waste generation rate as well as pollution load from different industrial sectors and to identify polluting industries as well as their exact locations for monitoring.
- Pilot Project to Recycle and reuse of Textile Effluent
- Preparing an easing plan to control environmental pollution in a practical manner rather than a reactive measure
- Preparing a national database on different types of industries operating in Bangladesh including SMEs, in order to identify the industries for monitoring.
- Promotion of ISO 14000 environment management principles

Waste management

- Assisting registered recyclers to establish Environmental Management System (EMS) and gradually work for ISO-14001 certification.
- Awareness raised on the environmental and health impacts of Mercury in each of the project countries.
- Capacity Building & Generation of CDM Benefit through Composting of Organic Waste of Urban Center (City Corporation & Municipalities) in Bangladesh.
- Commitment for technical up gradation of selected registered recyclers for processing E-waste.
- Develop E-Waste policy.
- Development of Hazardous Waste Management Facility.
- Establish efficient collection system for selected electronic waste
- Establish E-waste tracking mechanism in order to update the inventory.
- Establishment of division wise lead recovery and recycling centres/ plants for used out lead acid batteries
- Formulation decision-making structure for Hg operation.
- Implementation of Stockholm Convention requirements in all the stages of ship recycling.
- Implementation of Waste Reduce Reuse and Recycle (3R) Bangladesh.
- Improve technical capacities for environmentally sound management of PCB contaminated equipment and waste meeting BAT/BEP requirements.
- Institutional capacity and advocacy programs.
- Inventory of E-Waste in large cities of Bangladesh.
- Minimization/Elimination of uncontrolled POPS generation from the healthcare waste.
- Monitoring and Evaluation.
- National capacity built to undertake mercury inventories.
- National MinamataConventionInitial Assessments (MIA) report available each project country. (Environment, Forestry and Biodiversity conservation, Background Paper for Seventh Five Year Plan).
- Policy and regulatory framework, and institutional and capacity needs in regard to the implementation of convention provisions assessed.
- Registration of E-waste recyclers.
- Sound Management of hazardous waste.
- Strengthening of institutional and regulatory framework for PCBs,

Policy and legislations

- Bangladesh Biological Diversity Act, 2013 (Cabinet approved in principle)
- Bangladesh Bio-safety Rules, 2012
- Bangladesh Water Act, 2013
- Brick Manufacture and Brick Kiln Installation (Control) Act, 2013
- Ecologically Critical Area Management Rules, 2013.E-waste Rules, 2013.
- Environmental Conservation Act 1995 (Revision up to 2012)
- Environmental Conservation Rules 1997
- Environmental Pollution Control Ordinance, 1977
- Environmental Quality Standards, 1997
- Factories Act, 1965
- Fifth Five Year Plan (1997-2002):
- Hazardous Waste and Ship Breaking Waste Management Rules, 2011
- Integrated Pest Management
- National Agriculture Policy, 1999
- National Biodiversity Strategy and Action Plan for Bangladesh (NBSAP)
- National Conservation Strategy (NCS)
- National Environment Management Action Plan (NEMAP), 1995
- National Environmental Management Plan, 1995

- National Environmental Policy, 1992
- National Fisheries Policy
- National Policy for Safe Water Supply and Sanitation (1998)
- National Water Management Plan (NWMP), 2001
- National Water Management Plan, 2001
- National Water Policy (2012)
- National Water Policy (NWP), 1999-
- Odor Control Rules 2012.
- Pesticides Law,1985
- Solid Waste Management Rules, 2013
- Sustainable Environment Management Plan (SEMP)
- The EIA Guidelines for Industry
- The Environmental Court Act 2000
- The National Water Policy, 1999
- Water Pollution Control Ordinance, 1970
- Wetland Policy, 1998

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